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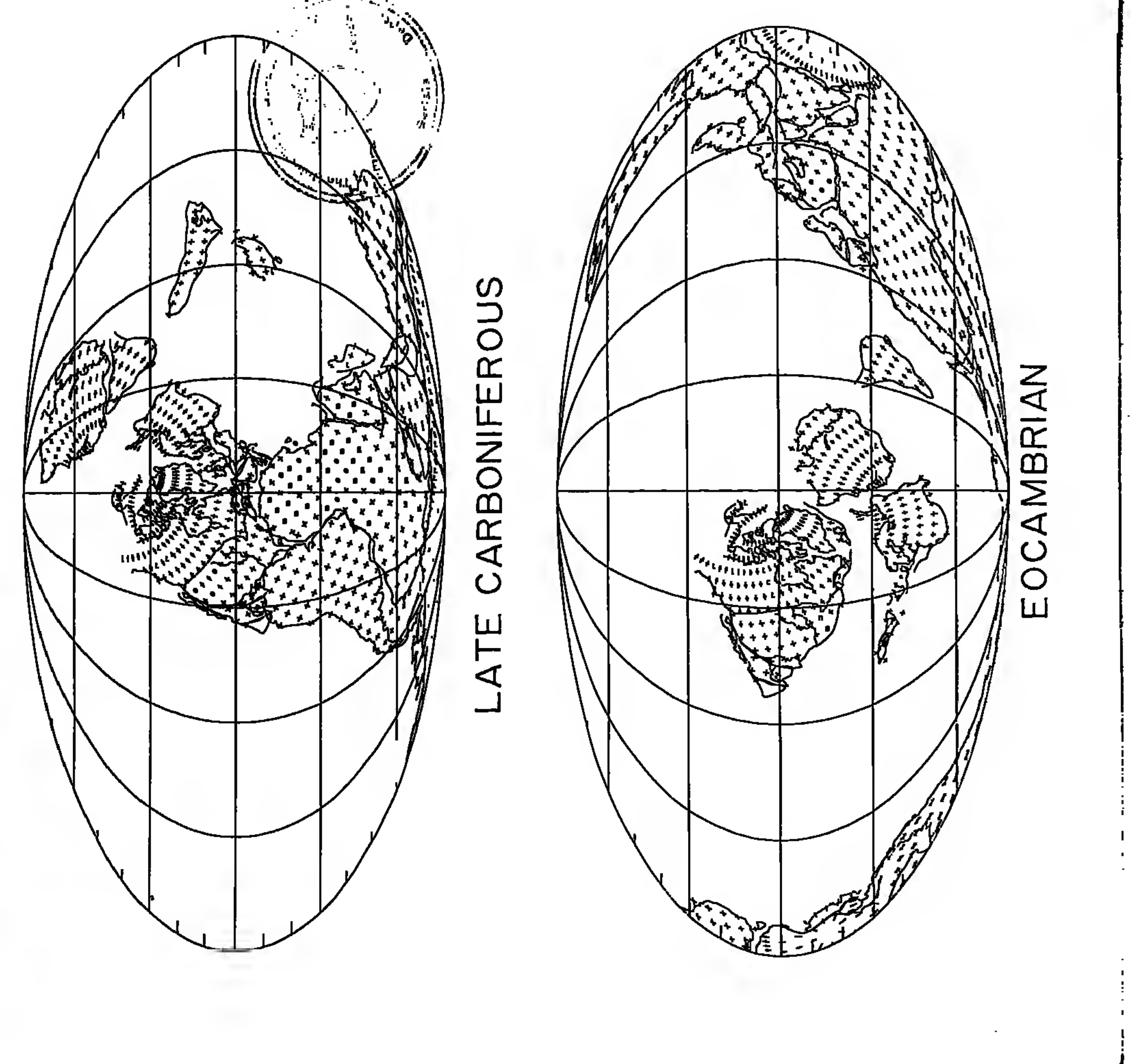

Eos, Transactions, American Geophysical Union Vol. 65, No. 11, Pages 97–104 March 13, 1984

Particles and Fields—Ionosphere

5540 Ion Densities and Temperatures
A TWO-DIMENSIONAL MODEL OF THE NIGHTSIDE IONOSPHERE OF VENUS: ION ENERGETICS
S. W. BOUGHER (Space Physics Research Lab, University of Michigan, 2455 Hayward, Ann Arbor, Michigan 48109), and T. E. Cravens
The energetics of the nightside ionosphere of Venus are still not well understood. Rather large ion temperatures have been observed on the nightside. We have constructed a two-dimensional theoretical model of the energetics of the nightside ionosphere which takes into account the effects of horizontal and vertical heat transport of heat. We demonstrate that the observed maintenance of the ion temperature can be explained in terms of these transport terms for solar zenith angles less than 150 degrees. Simple heat transport cannot explain the observed high temperatures for angles greater than 150 degrees.
J. Geophys. Res., A, Paper 4A0323

Tectonophysics

8150 Plate Tectonics
FAULTING ASSOCIATED WITH LARGE EARTHQUAKES AND THE AVERAGE RATE OF DEFORMATION IN CENTRAL AND EASTERN ASIA
P. Molnar (Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139), Deng Qidong
We determine approximate average rates of deformation in portions of eastern and central Asia for the last 80 years. These rates are based on estimates of course dimensions, average displacements, seismic moments and orientations of faults of all large earthquakes (M>7.5) and as many other major earthquakes (M≥7.0) as possible in Asia since 1900. A major part of this study is the compilation of these data. For separate parts of Asia, we combine seismic moment tensors to estimate the average rotational strain (or deformation) tensors for these regions for the last 80 yrs. We estimate that shortening across the Tien Shan has occurred at 11 mm/yr (between 5 and 19 mm/yr), left lateral shear on easterly trending planes in Mongolia, in northeastern Tibet, Gansu and Ningxia, and on the Xianshuihe fault in western Sichuan has been very rapid – more than 10 mm/yr in each region, and apparently as rapid as 48 mm/yr in northeastern Tibet, Gansu and Ningxia. Slower rates of n·1 to 18 mm/yr appear to characterize east-west extension and conjugate north-south shortening of Tibet. The earthquake history of the Himalaya is consistent with rates of underthrusting of much than 10 mm/yr, but probably less than the convergence rate of India with Eurasia of about 58 mm/yr. The overall strain field is consistent with a large part of India's penetration into Eurasia being absorbed by the extrusion of material out of India's way. As a result Southeast China moved at about 13 mm/yr east-southeast with respect to Eurasia in the last 80 years with an uncertainty of about a factor of two in this estimated rate. (S.E. China, Strain Rate)
J. Geophys. Res., B, Paper 4B0046

8158 Plate Tectonics (Alaska magnetical RELATIONSHIPS BETWEEN PLATE MOTIONS AND LATE CRETACEOUS TO PALEOGENE MAGMATISM IN SOUTHWESTERN ALASKA
Wesley K. Wallace (Regional Study Group, ARCO Alaska, Inc., P.O. Box 100360, Anchorage, Alaska 99510), and David C. Engebretson
Four major Late Cretaceous to Paleogene magmatic belts have been recognized in southwestern Alaska, and tentative boundaries have been drawn for each. The belts indicate minimum ages by which the tectonostratigraphic terranes they stitch must have been locked together, though there has been significant postmagmatic tectonics. The Kuskokwim Mountains belt (73–60 m.y. B.P.), the Alaska Range belt (74–55 m.y. B.P.), and the Gulf of Alaska belt (62–57 m.y. B.P.) all may have been related to a period of rapid north-northeastward motion of the Kula plate from about 74 to 56 m.y. B.P. The angle of convergence was low with respect to the present orientation of the belts, suggesting the possibility of postmagmatic rotation of the belts. A higher angle of convergence may have existed with respect to the Alaska Range belt, a probable arc, if postmagmatic rotation resulted from 300–400 km of right-lateral displacement on the Denali fault. The Gulf of Alaska belt is in an anomalous forearc position with respect to the Alaska Range belt, but probably formed by a convergence-related mechanism. The Kuskokwim Mountains belt is in an apparent back arc position, but the mechanism of its origin is uncertain. It may have been part of an unusually broad Alaska Range arc or, less likely, it may have been a separate arc. Magmatic quiescence occurred throughout southwestern Alaska during a period of plate reorganization from about 56 to 43 m.y. B.P., a period which began with extremely rapid northward motion of the Kula plate. Magmatism resumed when the present period of rather slow northwestward Pacific plate motion began at about 43 m.y. B.P. The Aleutian arc probably formed at this time, and has been episodically active in about the same location ever since. (Alaska, magmatic belts, plate motions, Denali Fault)
Tectonics, Paper 4T0032

8199 General (Fault scarp modification)
6950 Seismic Sources (Earthquake recurrence)
4740 Marine geological processes (Uplifted terraces)
MODIFICATION OF WAVE-CUT AND FAULTING-CONTROLLED LANDFORMS
T. C. Hanks (U.S. Geological Survey, Menlo Park, CA 94025), R. C. Bucknam, K. R. Lajoie, and R. E. Wallace
From a casual observation that the form of degraded fault scarps resembles the error function, this investigation proceeds through an elementary diffusion-equation representation of landform evolution to the application of the resulting equations to the modern topography of scarp-like landforms. The morphologic observations can be analyzed either in the form of one or more cross-strike elevation profiles or in the form of the slope-offset plot, a point plot of maximum scarp slope versus scarp offset. Working with either or both of these data representations for nine geologic structures, which range in age from 3 to 400 ka BP and in offset from 1 to 50 m, we apply analytical solutions for the vertical initial-value scarp, the vertical continuous-offset scarp, and the finite-slope initial-value scarp. The model calculations are intrinsically ambiguous, yielding as the final answer only the product κt (in the case of the initial-value problem) or the product κA⁻¹ (in the case of the repeated faulting problem); here t is the age of a single scarp-forming event, 2h is the vertical slip rate, and κ is the "mass diffusivity." A single profile across three seacliffs along the Santa Cruz, California, coast is analyzed as three separate initial-value problems. A reasonably constrained age for the seacliff standing above the Highway 1 platform returns κ = 11 GKE (1 GKO = 1 m²/ka). With this κ, we can date the two older seacliffs. In fact, we do the converse: age estimates for these two older seacliffs based on a uniform rate of uplift both yield the same κ as for the lower seacliff. We treat a single profile of the Raymond fault in Pasadena/San Marino in terms of the repeated faulting problem; for it the uplift rate of R. Crook and others yields κ ≈ 15 GKO. The very substantial pre-existing offset across the Raymond fault must have been buried/leveled some 250 ka BP, when the modern topography began to form. Our analysis of the lake Bonneville shoreline scarps reveals a dependence of κt on 2a, suggestive of non-linear modification processes. This appearance is treated with the finite-slope initial-value scarp model to determine κ = 1.1 GKO for the Lake Bonneville shoreline scarps. The suggestion of R. M. Machette that ~ 100,000 year-old, ~ meter-high scarps are "unobservable" in weakly consolidated alluvial terranes of the Basin and Range and Rio Grande Rift Valley provinces can be formulated as κ ~ 1 GKO. The coincidence between this inequality and the Lake Bonneville shoreline κ is striking, and it suggests that the value of κ = 1 GKO may be generally applicable, as a good first approximation, to the modification of alluvial terranes within the semi-arid regions of the western United States. The Lake Bonneville shoreline is the basis for dating four sets of fault scarps in west-central Utah. The Drum Mts. fault scarps can be modeled in several different circumstances, but the most likely interpretation is that these fault scarps formed as the result of a single episode of normal faulting 5.6 to 5.7 ka BP. The younger age is associated with quite low initial slope angles (25°). The other three sets of fault scarps show no evidence for finite initial-value slopes. Fault scarps along the eastern base of the Fish Springs Range are very young, 3 ka BP. We estimate the age of fault scarps along the western flank of the Oquirrh Mts. to be 32 ka BP, which meets the weak geologic constraint that they be older than the Lake Bonneville shoreline. Fault scarps along the northeastern margin of the Sheeprock Mts. are even older, 75 ka BP. An intriguing consequence of our single-event analysis of these scarps is that an 11.9 m offset occurred in a single earthquake.
J. Geophys. Res., B, Paper 4B0164

News

Ozone Depletion Estimates Lowered

Human activities deplete stratospheric ozone to a lesser degree than had previously been reported, according to a National Research Council (NRC) committee. The committee updated earlier NRC studies by reviewing recent research on the whether increased chlorofluorocarbons (CFC) and various trace gases would figuratively chip away at the envelope of stratospheric ozone that shields the earth from harmful ultraviolet radiation. The new estimates stem from improved mathematical models and from better measurements fed into the models.

Two different types of models were incorporated into the update. One considered only CFC, the other accounted for changes in a variety of trace gases. Both types suggest less change in total stratospheric ozone than had been previously estimated.

Atmospheric models that consider only the continued release of CFC at roughly current rates predict a 2–4% reduction in stratospheric ozone by the late 21st century, said the Committee on Causes and Effects of Changes in Stratospheric Ozone, part of the NRC's Environmental Studies Board. Equivalent estimates made by previous NRC committees in 1977 and 1982 forecasted a 15–18% reduction and a 5–9% reduction, respectively.

Other models, accounting for the effects of CFC and such trace gases as nitrous oxide, methane, and carbon dioxide, suggest that simultaneous changes in atmospheric concentrations of these gases could actually trigger an increase of about 1% in total stratospheric ozone during the next century. The committee noted, however, that when uncertainties in these models are considered, the result could range between an increase of a few percent to a decrease of up to 10%.

"Perturbations to ozone should not be considered separately from the issue of climatic alterations due to other trace gases such as carbon dioxide," stated the update committee, which is chaired by Leonard C. Harlter of Columbia University. "The so-called greenhouse effect may produce a cooling of the stratosphere, which would slow the rate of chemical reactions that destroy ozone."

The committee also said that detailed analyses of ozone concentrations from 1970 to 1980 produced "no discernible trend" in the total amount of ozone in the atmosphere. An apparent decrease in ozone may have been detected at an altitude of about 40 km in the stratosphere; this decrease must have been offset by increases in ozone at lower altitudes.

Requested by the Environmental Protection Agency as part of an ongoing congressional mandate, the study also examined the possible impact of increased ultraviolet radiation on human health, plants, and marine life. The committee's report, *Causes and Effects of Changes in Stratospheric Ozone: Update 1983*, is available for $15.50 from the National Academy Press.—*BTR*

Fusion Energy Breakthrough

The physics of harnessing nuclear fusion as a heat source is not well known. No such power generator has been made yet and significant breakthroughs will be necessary before the concept is proven. All such advances in energy research are followed with keen interest by geophysicists. One such breakthrough was made recently at the Massachusetts Institute of Technology (MIT) in experiments with a model Tokamak fusion reactor.

The MIT experimental high-field nuclear fusion reactor with the name of Alcator-C experienced a large technological advance when its operating parameters exceeded the so-called "Lawson criterion," one of the minimum requirements of a successful nuclear fusion power generator. The nuclear fusion of hydrogen to form helium releases heat, but to make such a process workable for a power plant, there must be a sizable efficiency in the ratio of energy input to bring about the reaction and the thermal energy released by the reaction, and even this advance falls far short of the breakeven point. The advance is, however, a great step in the learning curve about fusion magnetohydrodynamic plasma systems.

The breakeven point will be reached in the reaction when the product of the ion density and the energy confinement time exceeds a value of about 6×10^{14} sec cm^{-3} (the Lawson criterion), and the plasma temperature exceeds about 85×10^6 K (about 7.5 keV). In the MIT experiments, Alcator-C achieved a Lawson confinement parameter of about 8×10^{13} sec cm^{-3}, but the central temperature of the deuterium plasma was only about 17×10^6 K, still way below breakeven (*Physics Today*, February 1984). A nuclear reactor will need to exceed to breakeven conditions by a factor of 2 or more to be commercial.

Alcator-C was able to break the Lawson barrier by using a frozen deuterium pellet as fuel for the Tokamak. The pellets were fired into the central plasma region of the donut-shaped reactor by means of a sort of air rifle. The process had been tried at the Oak Ridge National Laboratory and was significantly better than the previous system, which injected puffs of gas into the outer confines of the plasma column. The object is to create a high plasma density and a long heat confinement time. In addition to ohmic heating of the plasma, external heat sources can be applied efficiently if thermal diffusion is low. Ohmic heating itself is limited by certain constraints on the maximum allowable plasma current. It would appear that with sufficient experimentation, auxiliary heating techniques may provide the next breakthrough.

Future trends depend crucially on the development of fusion power. Currently, conventional fission nuclear reactors are not being developed further in the United States. According to a recent finding by the Office of Technology Assessment, "Without significant changes in technology, management, and level of public acceptance, nuclear power in the U.S. is unlikely to be expanded in this century beyond the reactors already under construction." (*Chemical and Engineering News*, February 13, 1984). Other alternatives to oil burning are the use of coal and synthetic fuels.

Right now fusion power research is focused on the engineering and physics of plasma columns. The actual testing of a fusion generator will not be done for at least another decade.—*PMB*

EEZ Survey

The United States Geological Survey (USGS) has contracted with the Institute of Oceanographic Sciences (IOS) to charter the research vessel *Farnella*. The project is to map the ocean floor at depths greater than 500 m along the recently established United States Exclusive Economic Zone (EEZ). The short range objectives include obtaining seafloor contours along the deep sea thermal spring zones in the Pacific Ocean basin. Should any of the zones prove economic for their sulfide mineral deposits, the charts should be of value to industry for years to come.

According to a recent report, "In a few weeks time, the M. V. *Farnella* will sail for the west coast of the United States carrying the unique long-range sidescan sonar 'Gloria.'" (*Nature, 307*, 587, 1984). Gloria stands for Geological Long Range Inclined Asdic. The uniqueness lies in the sidescan sonar being optimized for geological observation. The functions of similar instruments in naval oceanographic vessels are often not suitable. Gloria uses a backscattering technique to provide imaging data from distances up to 30 m on either side of the track through the water. Other sonar systems are being used in the project as well, and thus a good comparison can be made.

The economic interest in the hot springs which are located at sites along the Pacific Basin ridges is associated with potential petroleum and sulfide deposits. The new Gloria maps may assist in isolating the deposits and in locating new ones.—*PMB*

In Congress

Year of Water

A resolution proclaiming 1984 as the "Year of Water" passed the Senate on February 27. "Water is our most precious natural resource," said Sen. Bill Armstrong (R-Ohio), who introduced S.J. Res. 202 in November. "The Year of Water will provide an opportunity to examine the issues surrounding water use and planning."

In addition to calling for "increased awareness and dedication to the interests of worldwide water resources and their immense importance in the welfare and well-being of mankind," the measure is intended to "welcome the delegates from the 79 member nations of the International Congress on Irrigation and Drainage" at their meeting in Fort Collins, Colo., in May and June.

The resolution was sent to the House of Representatives on February 28, and was referred to the House Committee on Post Office and Civil Service. A similar resolution also was introduced last autumn in the House of Representatives by Rep. Ray Kogovsek (D-Colo.).—*BTR*

Geophysicists

Bruce R. Doe, a member of the *Eos* board of editors, was recently appointed by the U.S. Geological Survey as the new assistant chief geologist for the eastern region.

Sierd Cloetingh, in the department of theoretical geophysics at Utrecht University, The Netherlands, is the recipient of Shell's 1984 travel award for his pioneering studies of passive continental margins and the initiation of subduction zones. Cloetingh is the first geophysicist to receive this award.

Recent Ph.D.'s

Eos periodically lists information on recently accepted doctoral dissertations in the disciplines of geophysics. Faculty members are invited to submit the following information, on institution letterhead, above the signature of the faculty advisor or department chairman:

(1) the dissertation title,
(2) author's name,
(3) name of the degree-granting department and institution,
(4) faculty advisor,
(5) month and year degree was awarded.

If possible include the current address and telephone number of the degree recipient (this information will not be published).

Dissertations with order numbers, and many of the others listed, are available from University Microfilms International, Dissertation Copies, P.O. Box 1764, Ann Arbor, MI 48106.

Adamello Complex: Aspects of Its Emplacement and Uplift, T. A. McRae, Dept. of Earth Sciences, Univ. of Cambridge, UK, 1983.

Age and Evolution of the Yukon Tanana Terrane, Southeastern Yukon Territory, J. K. Mortensen, Dept. of Geological Sciences, Univ. of California at Santa Barbara, 1983.

Barotropic Studies of Stationary Extratropical Anomalies in the Troposphere, J. L. Kinter III, Geophysical Fluid Dynamics Program, Princeton Univ., January 1984.

Barrovian Migmatites and the Thermal History of the South-Eastern Grampians, E. L. McLellan, Dept. of Earth Sciences, Univ. of Cambridge, UK 1983.

Basin Analysis of Volcanic Arc-Derived Jura-Cretaceous Sedimentary Rocks, Vizcaino Peninsula, Baja California Sur, Mexico, B. A. Barnes, Dept. of Geological Sciences, Univ. of California, Santa Barbara, 1983.

Carbon Isotope Analysis at the Nanogram Level Using Static Mass Spectrometry, I. P. Wright, Dept. of Earth Sciences, Univ. of Cambridge, UK, 1983.

Conodonts Through Time and Space. Studies in Conodont Provincialism, R. R. Charpentier, Dept. of Geology and Geophysics, Univ. of Wisconsin–Madison, May 1983.

Content and Isotopic Composition of Carbon in Stony Meteorites, M. M. Grady, Dept. of Earth Sciences, Univ. of Cambridge, UK, 1983.

Convergence Tectonics of the Peru Trench: 8°S–13°S Latitude, W. E. R. Warsi, Dept. of Oceanography and Geodynamics Research Program, Texas A&M Univ., December 1983.

Crustal Thinning in the North Sea, P. J. Barton, Dept. of Earth Sciences, Univ. of Cambridge, UK, 1983.

Devonian Geology of the Walls Peninsula, Shetland, T. R. Astin, Dept. of Earth Sciences, Univ. of Cambridge, UK, 1983.

Direct Examination of Biologically Active Copper in Seawater, N. R. Glunio-Zorkin, Dept. of Oceanography, Univ. of British Columbia, August 1983.

Distribution of Diatoms in the Surface Sediments of British Columbia Inlets, A. Roelofs, Dept. of Oceanography, Univ. of British Columbia, April, 1983.

Effects of Drilling Fluids and Turbidity on the Metabolic State of the Coral Acropora Cervicornis: Calcification Rate and Protein Concentration, J. J. Kendall, Jr., Dept. of Oceanography, Texas A&M Univ., December 1983.

Tectonics

John Dewey will complete his term as editor-in-chief of *Tectonics* at the end of 1984. Clark Burchfiel's term as North American Editor will also end. *Tectonics* is published jointly with the European Geophysical Society. This newest of AGU's journals has already established itself as an important journal bridging the concerns of geophysics and geology.

James A. Van Allen, president of AGU, has appointed a committee to recommend candidates for both editor-in-chief and North American editor for the 1985–1987 term. Recommendations of those interested in serving as editor or letters of recommendation from those who wish to suggest candidates should be sent to Tectonics Editor Search Committee, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, DC 20009.

Books

Groundwater Contamination in the United States

V. I. Pye, R. Patrick, and J. Quarles, University of Pennsylvania Press, Philadelphia, xxi + 315 pp., 1983, $35 cloth, $14.95 paperback.

Reviewed by John B. Robertson

Seldom has the sociotechnical community been more ready for a broad overview on an environmental issue than it is currently for a book on the subject of groundwater contamination in the United States. Many individuals, organizations, and institutions are asking: How much of our nation's groundwater resources are contaminated? Is our groundwater contamination problem getting worse and what is the longterm prognosis? What are the most significant causes of groundwater contamination and what are the most promising cures?

Groundwater Contamination in the United States addresses these and related questions but unfortunately does not provide very satisfying answers. However, this shortcoming is due primarily to insufficient data available for making such analyses—a point that the book brings out clearly.

The 14 chapters of the book are comprehensive in subject matter, including an executive summary; general groundwater hydrology; sources, extent, and severity of groundwater contamination; effects of contamination on public health; groundwater monitoring; remedial actions, protection strategies and aquifer classifications; and regulatory aspects. This broad range of topics, however, prohibits treating any one of them comprehensively; virtually every chapter subject is amenable to a separate treatise alone. Nevertheless, it does provide a good introduction to the state of knowledge and to most major references.

The study is based primarily on a review of easily available information, plus some new information solicited primarily from state agencies. It is the first time most of this information has been compiled, summarized, and analyzed in a single source. The text is generally clear and readable and relatively free of typographical errors. An irritating shortcoming is the overuse of clichés, understatements, and unsubstantiated generalizations, such as: "Pesticides have been found in ground waters in Arizona, California, New York, and elsewhere," and "Many products produced by our society are difficult to dispose of without harming the environment." A general weakness throughout the book is the liberal use of statements of "fact," data, and conclusions without proper reference to their source. This together with some serious inaccuracies, discussed below, tend to weaken the book's credibility. A typical unreferenced statement is, "In 1980, 88.5 billion gallons of ground water were used in the United States per day, and 68% of this was used for irrigation."

Other general criticisms include the lack of scales on any of the maps, and parts of the book appear to have been hastily prepared with inadequate understanding or literature research.

Although the executive summary (chapter 1) tends to gloss over the most important facts and information, the conclusions reached are reasonably complete, accurate, and justified. Chapter 2, "Options for Dealing with the Contamination of Groundwater," also tends to be too general and shallow. It would have been greatly improved by including some case histories. The portion of this chapter that addresses radioactive waste (page 27) is highly inaccurate, misleading, and incomplete. For example, the book states that no method has been agreed upon for disposal of high-level radioactive wastes, when, in fact, the United States and other countries have decided upon deep geologic disposal in mined repositories.

Chapter 3, "The Groundwater Resource," also conveys significant misconceptions and errors. Some typical examples are: "An unconfined or water table aquifer contains water under atmospheric pressure," (water below the water table is, of course, under pressure greater than atmospheric); "Movement of ground water occurs . . . along lines of hydraulic head" (movement of ground water occurs along stream lines, normal to lines of equal hydraulic head). The chapter implies that no good aquifers occur deeper than 2500 feet (750 m) below land surface, when, in fact, the western United States has many such deep aquifers. The chapter also fails to mention or emphasize the power and use of simulation models in studying groundwater flow systems.

Chapter 4 addresses the topic of "Groundwater Contamination" in a fairly general and acceptable manner. Some notable technical errors occur on pages 50–51, describing sorption and other processes affecting mobility of contaminants. The authors have confused the relationship of a contaminant's solubility with its mobility, have misstated the nature and reversibility of sorption reactions, and have inaccurately portrayed the significance of the octanol-water partitioning coefficient in assessing contaminant mobility in ground water. Table 4–3, listing components of various industrial wastes, is oversimplified, incomplete, and somewhat inaccurate. This chapter inadequately addresses the significance of contamination from sewage leakage, from fuel tank leakage, and the volatile chlorinated organic solvent sources. Like chapter 2, chapter 4 reflects major misunderstanding of nuclear waste classification, contamination, and disposal issues. For instance, it is stated in this chapter that contamination from low-level waste disposal sites is less well documented than disposal from high-level storage sites, when, in fact, the reverse is true; there are several documented cases of groundwater contamination (generally minor) from low-level waste sites.

An attempt is made in chapter 5 to analyze the "Severity of Groundwater Contamination" by reviewing a few semiquantitative estimates, made previously by others, of the area or volume of shallow aquifers potentially contaminated. The chapter fails to emphasize the severe limitations of these estimates and the fact that they do not include nonpoint sources of contamination (such as agriculture) which might account for more contamination than all the point sources.

Chapter 6 is a good review of information available on "The Effects of Groundwater Contamination on Public Health." As one might expect, there is evidence of many individual health problems from contaminated ground water, but the bottom line is that the data are very inadequate to make any nationwide assessment or appraisals; one of the more important statements in the book expresses this point superbly: "The lack of comprehensive nationwide surveys of the extent and severity of groundwater contamination and the paucity of groundwater contaminants that have actually been tested for carcinogenicity make it impossible to assess the national risk of drinking groundwater." Some good information is again contained in chapter 7, "The Geographical Extent of Groundwater Contamination." The chapter summarizes previous data compiled by the Environmental Protection Agency (EPA) as well as new information gathered for this book from surveys of 10 states. The depth of analysis is, however, disappointingly shallow and inconclusive. It would appear possible and useful to extract some projections, extrapolations, and estimates, particularly from the rather comprehensive New Jersey data, on the general extent and distribution of anthropogenic contaminants in at least some large-scale environments.

Chapter 8, "Monitoring the Quality of Groundwater," is a brief, general discussion with little usefulness to actual situations. Although it adequately presents general steps and approaches to monitoring, it fails to emphasize one of the most fundamental and important aspects of monitoring—understanding the flow system! It also fails to mention the importance of collecting ambient background data; the uses of surface and borehole geophysics in monitoring; and the application of soil gas sampling or "sniffing" techniques in monitoring.

"Remedial Actions and Rehabilitation of Aquifers" is the subject of chapter 9. Although the discussion adequately mentions most of the commonly known techniques, it fails to mention one of the most important and practical treatment methods for volatile contaminants—simple aeration. The chapter also fails to point out that microbiological decomposition treatment methods have been demonstrated to be viable commercially and are currently available from at least two or three private companies. The importance of computer simulation techniques to analyze and evaluate potential remedial action options should also have been discussed in this chapter. Groundwater protection strategies and aquifer classification concepts are discussed in chapters 10 and 11. Most of the discussion centers around the "dead horse" of the EPA's 1980 proposed groundwater protection strategy, which has since been withdrawn and is currently being totally redrafted.

Although it seems inappropriate to focus so much attention on a dead issue, there is some good discussion of the pros and cons of such strategies and their potential problems and limitations. The book presents a good review of the widely varying approaches by various states to aquifer classification, reflecting the diversity in philosophies and priorities on this issue from state to state.

Chapters 12, 13, and 14 are a review of existing federal statutes and state and local measures dealing with groundwater quality as well as proposed regulations. Although this provides a useful general review and summary of federal statutes, there is a significant shortcoming in the omission of regulations dealing with nuclear wastes, such as the Low-Level Waste Management Act of 1980 and the Nuclear Waste Policy Act of 1982. There also appears to be some redundancy in chapters 11 and 13.

Despite serious shortcomings and misconceptions, this book does contain a large amount of useful information available in no other single text; it should serve as a handy and useful reference to technical managers, administrators, and policy makers dealing with the issue of groundwater contamination. However, it should not be considered authoritative without referral to the primary source references. For the uninformed reader, there can be a danger of gaining an incorrect perception of how groundwater flow systems function, of how contaminants actually behave in groundwater, and of the significance of current and future groundwater contamination problems.

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Geochemistry of Sedimentary Ore Deposits

J. Berry Maynard, Springer-Verlag, New York, xi + 305 pp., 1983, $29.80.

Reviewed by Arthur W. Rose

Ore deposit geochemists and economic geologists have in the past directed most of their attention toward hydrothermal deposits, but it is becoming increasingly apparent that sedimentary deposits are of key future importance because of their size and other favorable characteristics. In addition, many deposits formerly considered hydrothermal are now recognized as sedimentary or as having important sedimentary affiliations. *Geochemistry of Sedimentary Ore Deposits* is the first to summarize and discuss the geochemistry of these important deposits, and it is therefore a welcome addition to the literature.

The definition for "sedimentary ore deposits" adopted in this book is "formed by sedimentary processes." Maynard therefore includes Mississippi Valley lead-zinc ores (formed by hot sedimentary brines) and volcanogenic sulfides (deposited on the sea floor) as well as iron formation and sedimentary copper ores. The emphasis is on chemical sediments, so that placers are not included, nor are nonmetallics such as evaporites. The coverage thus encompasses metallic deposits formed by syngenetic and diagenetic processes, plus epigenetic ores formed by sedimentary brines or hydrothermal fluid at the sea floor.

The main coverage of the book is divided by elements into seven chapters. For most elements or groups of elements sections discuss classification, mineralogy, geochemistry (with numerous new stability diagrams), petrography, vertical sequence (stratigraphy, sedimentary environment, and tectonics), and theories of origin. Some chapters include discussions of specific districts, and others cover modern deposits.

Another emphasis is on stable isotope studies. The book includes good discussions and extensive references on studies of C, S, and O isotope studies in sedimentary ores. Perhaps the most valuable features are Maynard's comments, interpretations, and research suggestions regarding applications of isotopes to determine rates of deposition, sources of components, and depositional environment of ores.

As an example of coverage, chapter 2 on iron divides discussion into banded iron formation and oolitic ironstones. As in other chapters, extensive tables list chemical data for various types and facies of iron ore as well as common rocks and iron minerals, and include discussion of rare earth data for iron ores. Algoma-type iron formations (relatively small deposits with an obvious volcanic association) are seen to have higher Ni, Cu, and Zn and lower Mn than Superior-type iron formation (extensive, with stable shelf association), and at least Archaean Algoma types have positive Eu anomalies, whereas Superior types have negative Eu anomalies. Eh-pH relations for a variety of facies are presented with emphasis on the importance of metastable initial precipitates like $Fe(OH)_3$ and FeS (mackinawite), later transformed by extensive diagenetic changes and low-grade metamorphism. For Superior-type iron formations, the light $\delta^{13}C$ in siderites suggests derivation of some C from decomposing organic matter; the variable oxidation state and mineralogy (facies) are attributed to varying amounts of original matter in the newly deposited sediment, after Drever (1974). Tectonic and sedimentologic environments are discussed, using stratigraphic relations, petrography, fossils, facies changes, and mineral composition. In origin, Maynard essentially follows Drever (1974) in attributing the Superior-type ores to a stratified ocean with high Fe^{2+} and SiO_2 below the thermocline, and precipitation of ferric minerals where deep water welled up and oxidized on the shelves. Difficulties explaining S and P contents are noted.

For ironstones like the Clinton ores of eastern U.S. or the Jurassic deposits of France and Great Britian, no clear method of origin is indicated, but many hypotheses are evaluated, and suggestions are made for productive research, such as isotopic studies of $\delta^{13}C$ and $\delta^{18}O$ in iron minerals. The coverage of literature is very extensive and broad, so the material should be valuable to researchers contemplating work on the subject.

Chapter 3 covers Cu and Ag deposits, which provide 25–30% of world Cu production. Types of Cu deposits include enriched supergene sulfide, and deposits in sandstone and shale (White Pine, Michigan), redbeds-evaporites (Creta, Oklahoma), and "controversial" deposits of the Kupferschiefer and central African Copperbelt. Although deposits and their sedimentary chemistry and environments are described, possible processes of formation are only suggested. Deposits of Al and Ni formed by residual weathering are covered in chapter 4. The lack of good explanations for Al mineralogy (gibbsite, boehmite, diaspore) is emphasized along with the lack of knowledge of the stability of the Ni minerals in Ni hosts. Chapter 5 covers manganese deposits and chapter 6 uranium deposits, including those in quartz pebble conglomerates, Proterozoic unconformity-veins, black shales, sandstones and calcretes. Lead and zinc deposits (chapter 7) are divided into carbonate-hosted Mississippi Valley Alpine, and Irish base metal types, and the clastic-hosted (Sullivan and MacArthur River) types. Volcanic-sedimentary ores (chapter 8) are discussed in a short chapter divided into those on divergent plate boundaries (Red Sea, Cyprus) and convergent boundaries (Kuroko).

Taken overall, this book is most valuable for its extensive literature coverage (750 references, up to 1981), wide disciplinary scope (ore deposits, sedimentology, petrography, isotopes, aqueous geochemistry, and mineralogy), innovative comments on processes, and suggestions for further research. It is also usable as a text or readings in specialized courses in mineral deposits and sedimentary geochemistry, but is weak in clear discussions of processes and origin, as well as the more physical and economic aspects of deposits. In any case, it is clearly the best review and synthesis of its kind and will be valuable to students and researchers on that basis.

Arthur W. Rose is with the Department of Geosciences, Pennsylvania State University, University Park, PA 16802.

Classified

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POSITIONS AVAILABLE

Faculty Position/University of Montana. The Geology Department of the University of Montana is inviting applications to fill a temporary, one-year position at the Assistant Professor level (contract period will be from mid-September 1984 to early June 1985). This position involves replacement of a faculty member on sabbatical leave. Ph.D. in geology is preferred; however, M.A.'s with teaching or professional experience will be considered. Students planning to complete their Doctorate during the 1984–85 academic year are encouraged to apply. Teaching responsibilities include undergraduate courses and introductory geology, mineralogy, petrology (sedimentary), and a seminar in area of special interest.

Those interested should send a letter of application, resume, three letters of recommendation to: Arnold J. Silverman, Chairman, Department of Geology, University of Montana, Missoula, MT 59812. The DEADLINE for applications is May 15, 1984.

The University of Montana is an affirmative action/equal opportunity employer.

EOS

Transactions, American Geophysical Union

The Weekly Newspaper of Geophysics

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Cover. During the past 10 years the U.S. Geological Survey has carried out teleseismic *P*-wave residual experiments in several geothermal and volcanic areas to detect and delineate magma bodies and to model the deep structure of these areas. The enclosed figure shows the locations of the *P*-wave residual experiments. Shaded areas represent approximate regions covered by the seismic networks used in these experiments. Lines are profiles of seismic stations. Names of volcanic features studied using the networks and profiles are indicated. Data from 2-dimensional networks yield 3-dimensional velocity models, whereas data from linear profiles yield 2-dimensional velocity models. The aperture of the seismic array determines the depth sampled. (Figure courtesy of H. M. Iyer, U.S. Geological Survey, M.S. 77, 345 Middlefield Rd., Menlo Park, CA 94025.)

Computer Programmer/North Carolina State University. Extension Specialist in Biological and Agricultural Engineering. M.S. degree preferred, B.S. required. Position requires strong experience in computer programming and data base management in addition to a working knowledge of statistics. Ability to program in a structured language and experience with SAS preferred. The person selected will interact with environmental scientists to build and analyze a data base on water quality programs nationwide. Salary range $20,000–$25,000 based on experience. Send resume and the names of three references by April 15, 1984, to:

Dr. Michael D. Smolen
National Water Quality Evaluation Project
622 Downtown Blvd.
Raleigh, NC 27603

North Carolina State University is an equal opportunity/affirmative action employer.

Research Associate/M.I.T. Qualified applicants are sought for the position of Research Associate in the Department of Earth, Atmospheric, and Planetary Science's Earth Resources Laboratory. Individual to be the group leader and conduct independent research in the measurement of the physical properties of sedimentary rocks. Individual must have experience in the laboratory measurement of acoustic, electrical, thermal and flow properties of both rocks and soft sediment. The candidate should also possess a basic knowledge of igneous, metamorphic, and sedimentary petrology, as well as familiarity with the interpretation of SEM photographs of rocks. A Ph.D. in geological sciences, plus at least three years of postdoctoral research experience, are desired.

This is a permanent research staff position. Applicants should submit resume, publication list, and names of three references to:

William F. Brace
c/o Muriel Birchene
Personnel Office, E19-239
M.I.T.
77 Massachusetts Avenue
Cambridge, MA 02139

M.I.T. is an Equal Opportunity/Affirmative Action Employer.

University of Arizona/Research Associate. Applications are invited for two possible positions as research associate in theoretical plasma astrophysics, solar physics and/or cosmic-ray astrophysics.

The successful applicant for the first of the positions will be expected to devote a substantial part of his or her research to problems in solar or interplanetary physics. This position can be filled as early as Spring 1984 and applications should be received by April 30, 1984.

The second position involves research on cosmic rays and their interactions, in the solar wind or elsewhere. This position can be filled in Fall 1984, and applications should be received by July 31, 1984.

Applicants for either position should possess a Ph.D. in a relevant area of physics, astronomy, or planetary sciences.

Inquiries and applications should be addressed to Professor J.R. Jokipii or Professor E.H. Levy, Department of Planetary Sciences, University of Arizona, Tucson, AZ 85721.

Applicants should send a resume, complete bibliography, and arrange for at least three letters of recommendation from persons who are well-acquainted with the applicant's background and potential in research.

The University of Arizona is an equal opportunity/affirmative action, Title IX, Section 504 employer.

Radioisotope Geochemistry/University of South Carolina. We anticipate a one or two year postdoctoral position classified as *Research Assistant Professor with a salary of $18,500 per year* starting as early as May, 1984. Applicants must have completed all Ph.D. requirements. Priority will be given to persons with expertise in radioisotope geochemistry with an interest in establishing an innovative research program. Facilities are available for low level alpha and gamma spectrometry, including an intrinsic germanium detector with a 1 cm well, 100 cm³ Ge(Li) detector and 12 alpha spectrometers as well as low level beta and radon counters.

Send resume, detailed statement of research interests and names of three references to:

Dr. Willard S. Moore, Chairman
Department of Geology
University of South Carolina
Columbia, SC 29208

The University of South Carolina is an equal opportunity/affirmative action employer.

Senior Applications Chemist. Kevex Corporation is seeking an individual with a strong Analytical Chemistry background, in particular in X-ray Fluorescence, for Applications Laboratory.

Three years of experience in Lab or Industrial Analytical Problem solving using XRF is required. Advanced degree in Physical Science or Engineering is preferred. Position requires Applications support to Marketing, Sales and R&D operations. Submit resume to: Mr. Drew Isaacs, Kevex Corporation, 1101 Chess Drive, Foster City, CA 94404.

EOE M/F/H/V.

William M. Rice University/Geophysics and Reflection Seismology. As part of a Rice University commitment to develop further a modern Earth Science program, we plan to expand our geophysical faculty beginning in the summer of 1984 and are seeking to fill three open positions, including two endowed chairs. We wish to build a team of collaborators interested in developing a new and outstanding program of fundamental research and teaching in reflection seismology and practical capabilities, including seismic data processing. Enthusiasm to work with and undertake some joint projects with our geologists is essential.

In support of these objectives the group will be expected to assist in developing innovative graduate and undergraduate curricula, which are supported by the traditional strength of the Mathematics, Mathematical Sciences and Electrical Engineering Departments at Rice.

The group will also be expected to acquire and develop a seismic processing center. Funds for the center and some initial research funds are already available, but an aggressive search for additional research funds will also be necessary. In this context creative interaction with the oil industry is encouraged. There are also consulting opportunities in Houston.

Salaries and titles will be commensurate with qualifications and experience. Please send your curriculum vitae, research experience (including a summary of experience in seismic processing), a short outline of a research program you would like to undertake and names of three or more references to Dr. A. W. Bally, Chairman, Department of Geology, Rice University, P.O. Box 1892 Houston, Texas 77251.

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CSIRO conducts scientific and technological research in laboratories located throughout Australia and employs about 7,500 staff, of whom some 2,900 are professional scientists. The Organization's research activities are grouped into five Institutes: Animal and Food Sciences, Biological Resources, Energy and Earth Resources, Industrial Technology and Physical Sciences. The CSIRO Division of Oceanography is a member of the Institute of Physical Sciences.

GENERAL: The CSIRO Marine Laboratories, which include the Division of Oceanography and the Division of Fisheries Research, is Australia's principal marine research institution, employing over 200 scientists and support staff investigating the physical, chemical and biological features, including fisheries, of the oceans around Australia.

Two well equipped chartered vessels (53m and 43m) are used for research and a modern oceanographic ship is being built to replace the 43m vessel. The Marine Laboratories have a VAX 11/750 computer, while on-line access to a Cyber 76 computer is available.

New laboratories are nearing completion in Hobart.

DUTIES: The appointee will lead a small group concerned with the measurement of nutrient and other chemical data from Australian regional seas and open waters and their analysis and interpretation in the context of the dynamics of the water, sources and sinks, transfer, biological consumption and conversion. A suitable appointee may be invited to assume overall responsibility for the Division's Ocean Characterization program which includes Trace Metals, Organic Chemistry, Nutrient Dynamics and Ocean Monitoring sub-programmes

QUALIFICATIONS: A PhD degree or equivalent qualifications with extensive experience and substantial original research achievement in the field of chemical oceanography. Preference will be given to an applicant who has demonstrated interest and expertise in the development of descriptions and dynamical models of chemical status of open water features through the combination of both physical and chemical measurement.

TENURE: This is an indefinite appointment with Australian Government superannuation benefits available.

APPLICATIONS: Stating full personal and professional details, the names of at least two referees, and quoting reference No. A5861, should be directed to:

The Chief
CSIRO Division of Oceanography
GPO Box 1538
HOBART TAS 7001
AUSTRALIA
by April 16th 1984.

HANFORD

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The Rockwell International-managed Hanford Reservation in Richland, Washington is a multi-plant chemical processing and nuclear waste management facility. Join us as we investigate the feasibility of forming a nuclear waste repository within basalt flows underlying the Hanford Reservation. Current opportunities in support of the Basalt Waste Isolation Project include:

Field Hydrologist

To plan, conduct and document borehole hydrologic tests. Requires minimum 7 years experience in field testing with a degree or equivalent combination of education and experience. Knowledge of downhole geophysics and drilling techniques desirable.

Hydrogeologist

Assist in interpreting, integrating and documenting hydrologic data to evaluate the groundwater flow characteristics of a basalt medium. Advanced degree with minimum 6 years experience in field testing and model development required.

Hydrochemist

Plan, coordinate and interpret the results of a variety of field solute transport and geochemical tests. Advanced degree and a minimum of 4 years relevant experience in geochemistry and hydrology required.

When you bring your expertise to Rockwell International, you'll receive an outstanding compensation and benefits package, including company-paid medical, dental and life insurance, relocation assistance, plus generous savings and retirement plans. Please forward your resume in confidence to:

B.E. White (B21EOS3/20), Rockwell International, Hanford Operations, P.O. Box 800, Richland, WA 99352. Equal Opportunity Employer M/F. U.S. Citizenship Required.

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Physicist/ Atmospheric Scientist

The Lawrence Livermore National Laboratory is an R&D facility operated by the University of California for the U.S. Department of Energy. Located in the San Francisco East Bay Area, the Lab employs 8,000 individuals engaged in challenging basic and applied R&O. Currently we are seeking a Physicist/ Atmospheric Scientist to join the Atmospheric and Geophysical Sciences Division of our Physics Department.

In this position your research will emphasize the design of improvements for and use of a three-dimensional general circulation model for fundamental investigations of atmospheric dynamics, thermodynamics and applications on Laboratory programs. The initial emphasis of this position will be on the application of an improved general circulation model to study the global-scale atmospheric affects of a nuclear exchange. Additionally, you will be responsible for providing direction to computer programmers that will assist in software development and operation of the code.

For this position we require an individual with a PhD or equivalent work experience in atmospheric sciences, demonstrated leadership ability, and experience in conducting independent research with global circulation models. Specific expertise in such areas as atmospheric dynamics and thermodynamics is highly desirable.

Lawrence Livermore National Laboratory offers competitive salaries, a liberal benefits program including health, dental, broadbased retirement and up to 20% tax deferred annuity programs.

To apply for this position, please send your resume, in confidence to: **Art Wong, Professional Employment Division, Lawrence Livermore National Laboratory, P.O. Box 5510, Dept. KES-034, Livermore, California 94550.**

U.S. Citizenship is required.
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University of California
Lawrence Livermore National Laboratory

Postdoctoral Position in Physical Oceanography or Meteorology. Available for research on the oceanic or atmospheric aspects of climate in collaboration with CIMAS Fellows and using the facilities of the Rosenstiel School of Marine and Atmospheric Science and NOAA's Atlantic Oceanographic and Meteorological Laboratory. One-year appointment extendable to two years. Salary to $27,300 based on experience. Applicants should submit a resume, a statement of research interest and the names of three references to:

Dr. William W. Fox, Jr., Director
Cooperative Institute for Marine and Atmospheric Studies
RSMAS/University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149
(305) 361-4185.

An Equal Opportunity/Affirmative Action Employer.

Physicist. The National Oceanic and Atmospheric Administration (NOAA) announces a Physicist, GS-13, vacancy in the Environmental Research Laboratories, Space Environment Laboratory, Supporting Research Division, Boulder, Colorado. Starting salary at GS-13 level is $36,152. Duties include conducting research on the physics of the solar corona as related to the emission of matter and radiation which result in disturbances in the near-earth environment. Demonstrated achievement in basic astrophysical research is required. For further information and application procedures, please call Mary Plumley, NOAA Personnel at (303) 497-3102. Applications must be received by March 30, 1984, to be considered.

An equal opportunity employer.

Ground Water Hydrologists. Environmental Science and Engineering, Inc., a full service Engineering consulting firm based in Gainesville, Florida, with regional offices in Florida, St. Louis, Denver, and Baton Rouge, has openings for ground water hydrologists to manage projects, prepare proposals, and make presentations to clients. Projects include hazardous waste investigations and remedial engineering, ground water monitoring and contamination assessments, geophysical studies, ground water supply development and permitting, landfill siting and permitting, and land application of wastewater. Preferred qualifications include an M.S. degree in Geology or Engineering/Professional Registration, and a minimum of 3 years progressive experience involving hydrogeology, hazardous wastes, and water resources.

ENVIRONMENTAL SCIENCE
& ENGINEERING,
DEPARTMENT # GO
P.O. Box ESE
Gainesville, FL 32602.
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Physical Oceanographer. The Ocean Research Division of Scripps Institution of Oceanography announces an opening at the post-doctoral or career-entry level (Ph.D. or equivalent degree required) for a physical oceanographer with experience and interest in coastal oceanography. Applicants with theoretical or observational backgrounds are invited. Salary will be provided for two years during which time the successful candidate will be expected to work in cooperation with SIO staff investigating coastal dynamics in conjunction with the CODE, OPUS and/or CalCOFI programs. After two years a career employee will be expected to raise his/her own salary. Level of appointment and salary range $19,392–26,100 commensurate with qualifications.

Send resume and references to Ross Davis, Ocean Research Division A030, Scripps Institution of Oceanography, La Jolla, CA 92093 by April 30, 1984.

University of California, San Diego is an Equal Opportunity/Affirmative Action Employer.

POSTDOCTORAL APPOINTMENT IN ANALYTICAL, SEPARATION OR RADIOCHEMISTRY

The Isotope Geochemistry group of the Los Alamos National Laboratory is seeking candidates for a postdoctoral appointment in analytical, separation or radiochemistry.

This opportunity will include participation in a solar neutrino experiment [Science **216**, 51 (1982)] with involvement in separation and purification of trace quantities of technetium from large quantities of molybdenite. Experience in wet chemical separation is required.

The Laboratory, one of the nation's foremost scientific research organizations, is operated by the University of California for the U.S. Department of Energy. Our location in the mountains of northern New Mexico offers an uncrowded lifestyle with ample recreational activities.

Our postdoctoral appointments are for one year, renewable for a second year and pay a stipend amount of $26,200 to $27,600 per annum. We provide employee benefits, including incoming travel and moving expenses. Candidates no more than three years past their Ph.D. are invited to apply. U.S. Citizenship is required.

Send your resume in confidence to:

Madeline Lucas, DIV 84-AT
Personnel Services Division
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

University of California
LOS ALAMOS
An Affirmative Action/Equal Opportunity Employer.

Air Force Geophysics Laboratory Geophysics Scholar Program (1984–1985). The Air Force Geophysics Laboratory (AFGL) and The Southeastern Center for Electrical Engineering Education (SCEEE) announce that applications are invited for research appointments during the 1984–1985 year in the Geophysics Scholar Program. This program provides research opportunities of 10 to 12 months duration for selected Engineers and Scientists to perform research in residence at the AFGL, Hanscom AFB, near Boston, Massachusetts. Scholars will be selected primarily from such fields as Geophysics, Atmospheric Physics, Meteorology, Ion Chemistry, Applied Science, Mathematical Modeling using Computers, and Engineering.

To be eligible, candidates must have a Ph.D. or equivalent experience in an appropriate technical field. Some appointments may be confirmed prior to August 1984 so early applications are encouraged. All qualified applicants will receive consideration without regard to race, color, religion, sex, or national origin. Application Deadline for September Appointments: August 1, 1984. For further information and application forms contact: SCEEE, 1101 Massachusetts Avenue, St. Cloud, FL 32769 Telephone: (305) 892-6146.

SCEEE supports Equal Opportunity/Affirmative Action.

University of New Mexico/Paleomagnetism. The Department of Geology of The University of New Mexico invites applications for a tenure track full-time position as an Assistant Professor with a specialty in paleomagnetism beginning Fall 1984. The successful candidate will be expected to maintain an active research program and teach at the undergraduate and graduate level. The Department has sixteen full-time faculty, is located in a spectacular natural setting and has excellent analytical facilities.

Applicants should submit a resume, transcripts, and three letters of recommendation to R. Ewing, Department of Geology, Albuquerque, New Mexico 87131. The deadline for applications is April 10, 1984.

The University of New Mexico is an equal opportunity/affirmative action institution.

Statistician/Water Resource Research. Excellent opportunity with Wyoming Water Research Center and Department of Statistics at the University of Wyoming, to perform statistical/mathematical research, consult in parametric and stochastic hydrology, interact with state agencies, and teach limited classes, including guidance of graduate student research. Requires a Ph.D. with demonstrated research ability in applied statistics, probability modeling and stochastic processes related to water problems. Mathematical and computer applications, i.e., simulation and programming, as well as prior consulting are also preferred. This tenure track position provides rank and salary commensurate with experience. Our location in the Medicine Bow Range of the Rocky Mountains offers abundant recreational opportunities. Write Dr. Leon Borgman, Department of Statistics, University of Wyoming, Laramie, Wyoming 82071.

An equal opportunity/affirmative action employer.

The University of Texas at Dallas/Postdoctoral Openings. The University of Texas at Dallas occasionally has postdoctoral openings in the Physics Program. Current research areas include: XUV Lasers and Laser Spectroscopy (C. B. Collins and C. D. Cantrell), Space Plasma Physics (W. B. Hanson and W. J. Heikkila), Space Optics (B. A. Tinsley), Cluster Ion Studies (A. J. Cunningham), Solid State Physics (R. Glosser and R. Chaney). Stipends are competitive. Interested applicants should send vita (indication of sex and ethnicity for Affirmative Action Statistical purposes is requested but not required), and names of three references to: Physics Department, UT-Dallas, P.O. Box 830688, Richardson, TX 75083–0688.

UT-Dallas is an Affirmative Action/Equal Opportunity Employer.

Research scientists/University of Colorado. The Laboratory for Atmospheric and Space Physics at the University of Colorado seeks qualified research scientists in the field of atmospheric physics.

The successful applicant(s) would conduct research with the scientific team at LASP analyzing more than two years of Solar Mesosphere Explorer (SME) data. The extensive data base includes global measurements of ozone, temperature, water vapor, nitrogen dioxide and other parameters of the Earth's Mesosphere and Stratosphere. A doctorate or its equivalent in a relevant subject is necessary. The person(s) selected must be capable of conducting individual research and working as part of a scientific team. A background in solar, planetary or atmospheric sciences is desirable. Salary commensurate with experience. Applications including a current professional resume and names of three references should be sent to:

Dr. R.J. Thomas
Laboratory for Atmospheric & Space Physics
Campus Box 392
University of Colorado
Boulder, Colorado 80309.

Applications are being accepted on a continuous basis.

The University of Colorado is an equal opportunity/affirmative action employer.

Research Position in Space Plasma and Auroral Physics. Two research positions at the level of assistant or associate research scientists are available in the Department of Physics & Astronomy at the University of Iowa for qualified candidates with a Ph.D. degree and experience in space plasmas and/or auroral physics. Present research in space plasma physics emphasizes analysis and interpretation of observations of magnetospheric plasmas using instrumentation on board earth-orbiting spacecraft in the IMP and ISEE Missions. The University of Iowa's global imaging instrumentation on the spacecraft Dynamics Explorer 1 is the source of an extensive data base of auroral images from high altitudes at visible and ultraviolet wavelengths. Photometric observations are also available for other areas of research including the physics of the upper atmosphere and the global distribution of atmospheric ozone. The applicant should identify and describe areas of his or her expertise which can support experimental or theoretical investigations in space plasma physics and/or auroral physics. Salary and position will be determined by the applicant's qualifications and experience.

A resume and the names of three persons knowledgeable of applicant's experience should be forwarded to: L. A. Frank, Department of Physics & Astronomy, University of Iowa, Van Allen Hall, Iowa City, Iowa 52242.

The University of Iowa is an affirmative action/equal opportunity employer.

GEOCHEMIST

OAK RIDGE NATIONAL LABORATORY'S Environmental Sciences Division is seeking applicants in the following areas: (1) *Geochemical Modeling* and (2) *Environmental Geochemistry*. The Environmental Sciences Division is a multidisciplinary organization with research activities ranging from fundamental investigations to design and evaluation of mitigative actions for environmental problems. Successful applicants will be expected to work with hydrologists, geologists, and soil scientists as well as other geochemists in coordinated programs. Ongoing major programs include waste management-related studies and transport and fate of trace substances. Also, growth in global biogeochemistry has begun.

Candidates should have a Ph.D. in geochemistry or an advanced degree with experience. Emphasis on scholarly achievement and publications will be expected. U.S. citizenship is required.

GROUNDWATER HYDROLOGIST

OAK RIDGE NATIONAL LABORATORY'S Environmental Sciences Division is also seeking groundwater hydrology candidates with an interest in applied research and experience in carrying out groundwater investigation and evaluations for groundwater contamination problems. Expertise in geophysical techniques and/or aquifer testing would be a plus.

Candidates should have a Ph.D. or an advanced degree with experience. Emphasis is on academic achievement and timely publication of new information. U.S. citizenship is required.

ORNL offers an excellent salary and benefits package and a generous relocation program plus a stimulating working environment and superb facilities.

Qualified candidates should forward resume, three letters of recommendation, academic transcripts, and salary requirements to:

**Mr. J. T. Atherton
Technical Employment Manager
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37831**

AN EQUAL OPPORTUNITY EMPLOYER

Ocean Turbulence/Oregon State University. Join us in studying turbulence in equatorial waters! A postdoctoral position is available at Oregon State University in a project entitled "Turbulent Transports in TROPIC HEAT." The successful applicant will assume a major share of the responsibility for deployment of vertical profiling ("microstructure") instruments on the first TROPIC HEAT cruise in November 1984 and then will share responsibility for scientific analysis of the data obtained. The starting date is nominally 1 August 1984, but is somewhat negotiable. Starting salary is $26,000 yearly. Applicants must have a Ph.D. in the physical sciences or engineering and must be capable of performing independent research on oceanic turbulence. Applications must be received by 31 March 1984 by:

Douglas R. Caldwell
College of Oceanography
Oregon State University
Corvallis, OR 97331.

Oregon State University is an affirmative action/equal opportunity employer and complies with section 504 of the Rehabilitation Act of 1973.

Howard University/Graduate Faculty Position. The Department of Geology/Geography invites applications for a tenure track position in geochemistry at rank of Graduate Associate Professor beginning August 1984. Position involves development of graduate research program at Master's level. Specialization in environmental geochemistry/geochronology/isotope geology desired. Send letter of application, resume and names of three references to: Dr. David Schwartzman, Department of Geology/Geography, Howard University, Washington, DC 20059.

Research Scientist. Major University in Southern California has opening for research scientist in experimental deep upper mantle petrology, both synthetic and natural systems. Research to characterize mineralogy and chemical constitution of lithospheres. Salary $1,400 per month. Candidate must have Ph.D. in geology and be able to utilize piston-cylinder devices and electron microprobe analysis. Send resume to: Box 021, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009.

CHIEF SCIENTIST

BUREAU OF METEOROLOGY RESEARCH CENTRE

MELBOURNE – AUSTRALIA

SALARY $A55050

Applications for the position of Chief Scientist to lead the recently created Bureau of Meteorology Research Centre (BMRC) are invited from scientists with an established record of personal research achievement and leadership in an appropriate field of science.

The Chief Scientist will be responsible for the leadership, scientific direction and coordination of the research programs of the BMRC and will be encouraged to promote active collaboration with appropriate divisions of the Commonwealth Scientific and Industrial Research Organization (CSIRO), universities and other institutions, both in Australia and overseas, conducting research in relevant areas.

GENERAL

The Bureau of Meteorology is established within the Commonwealth Department of Science and Technology and has a total staff of approximately 1 700 located throughout Australia. The Bureau, as the national meteorological authority, is responsible for the provision of meteorological services throughout Australia and its territories and for the conduct of meteorological research. To meet these diverse responsibilities it operates modern facilities, many at the forefront of technology, including a major centralised computing installation.

Following a recent reorganisation the Bureau will be substantially upgrading its meteorological research role through the establishment of the BMRC which will operate as an essentially self contained research institute. It is proposed that the Centre will be staffed by a mix of Research Scientist and Meteorologist classifications with appropriate internal computing, administrative and technical support. Its role will be to serve as a national meteorological research facility. In this context the purpose of the BMRC will be the advancement of meteorological science with emphasis on improved understanding of Australian weather and climate and improvement in the quality of the Bureau's services.

A salary of $55050 will be offered to the successful applicant. Current salaries are adjusted half-yearly to account for general community cost of living increases.

CONDITIONS

The successful applicant will be offered an initial fixed term engagement for an agreed period as Chief of the BMRC. Re-engagement for a further period may be available. Appointment to an appropriate permanent position within the Bureau may also be available to the successful applicant should the initial term appointment of Chief of BMRC not be renewed.

Conditions of service include 4 weeks' annual recreation leave, cumulative sick leave, 3 months' long service leave after 10 years, an annual leave loading and a comprehensive superannuation scheme. Assistance with removal costs will also be available, if required.

Telephone enquiries may be directed to Dr D J Gauntlett, Deputy Director (Research and Systems) Telephone: Melbourne 669 4371

Applications stating full personal and professional details and the names of at least three referees should reach:

Director of Meteorology
PO Box 1289K
MELBOURNE Vic 3001
AUSTRALIA

by 30 April 1984

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**Employment Manager
Personnel Department
Texas A&M University
YMCA Building
College Station, TX 77843.**

Information about the position:
Dr. M. C. Gilbert
409-845-2464

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Research in Space Plasmas, Solar and Heliospheric Physics. The National Research Council offers Resident Research Associate awards in many areas of research; in particular, awards are available at the Jet Propulsion Laboratory in the area of Space Plasma Physics and Solar and Heliospheric Physics, as well as other areas. Areas of research available at JPL include studies of the solar wind, cometary plasma interactions, solar oscillations, magnetospheres of the Earth, Jupiter, and Saturn, plasma waves both in the solar wind and the magnetosphere, and the numerical modeling of space plasmas.

For further information about research opportunities at JPL in these research areas, please contact any of the individuals listed below:

Bruce E. Goldstein (213) 354-7366
Marcia Neugebauer (213) 354-2005
Edward J. Smith (213) 354-2248
Bruce T. Tsurutani (213) 354-7559

All individuals at Jet Propulsion Laboratory, Mail Stop 169/506, 4800 Oak Grove Drive, Pasadena, CA 91109.

Awards are available both at the postdoctoral (Regular) level and the Senior Research Associate level. Awards are initially for a period of one year; on some occasions an extension is allowed. Awards to Senior Associates are generally for one year but shorter periods will be considered.

Detailed information on application procedures, all necessary forms, and a list of supporting documents required are available upon request from:

Associateship Programs (JH 608-D1)
National Research Council
2101 Constitution Avenue, N.W., Washington, D.C. 20418.

Staff Position/Department of Terrestrial Magnetism. The Department of Terrestrial Magnetism of the Carnegie Institution of Washington invites applications for a staff position in geochemistry. Applicants should have a demonstrated ability for active and innovative independent research using trace-element and/or isotopic techniques to investigate the origin and geochemical evolution of the solid earth.

Applicants should send a resume and have three letters of reference forwarded by May 15 to:

Geochemistry Staffing Committee
Department of Terrestrial Magnetism
5241 Broad Branch Road, N.W.
Washington, D.C. 20015

Starting time for the appointment is flexible though a target date of late 1984 is preferred.

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Interested candidates should call or write:

**Marine Science Coordinator's Office
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Geological Observatory
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Palisades, New York 10964
914-359-2900 extension 367.**

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Washington State University

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- Geohydrology: A strong background in the geological sciences and a high level of proficiency in numerical modeling is highly desirable.
- Geophysical exploration background is also desirable.
- Geophysics: A strong background in borehole geophysics with interest in geohydrology and evaluation of geotechnical properties of rock is highly desirable.

The successful applicant will teach undergraduate and graduate level courses in geohydrology and/or geophysics and be expected to take over an established research program involving graduate students. Professional registration, or qualifications to obtain such registration, is desirable. Qualified applicants should send a resume, copies of undergraduate and graduate transcripts, and at least three letters of recommendation to: Dr. Surinder K. Bhagat, Chairperson, Department of Civil and Environmental Engineering, Washington State University, Pullman, Washington 99164-2910 by April 7, 1984. Washington State University is an equal opportunity/affirmative action employer.

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STUDENT OPPORTUNITIES

Research Assistantships/University of Maryland. The Meteorology Department of the University of Maryland has research assistantships available for graduate students, Fall Semester 1984. The Department offers courses of study leading to the degrees of Master of Science and Doctor of Philosophy in meteorology. Students with a bachelor's degree in meteorology, the physical sciences, mathematics, or engineering are invited to apply.

Situated in the Maryland suburbs of Washington, D.C., the University is in an ideal location for interaction with the large meteorological community of the area. The Department has cooperative research agreements with the National Oceanic and Atmospheric Administration and the National Aeronautics and Space Administration. Access to facilities of these and other government agencies, including the large computers at the National Center for Atmospheric Research and NASA, are important resources for students at Maryland. The Cooperative Institute for Climate Research and the Center for Ocean-Land-Atmosphere Interactions, both established recently on campus, offer student expanded opportunities for advanced study and research in climate analysis, modeling and prediction. A large number of private and government agencies within the metropolitan Washington, D.C. area offer employment opportunities.

Interested individuals are encourage to write for more information to the following address: Chairman, Department of Meteorology, University of Maryland, College Park, MD 20742.

Research Fellowships at the University of Notre Dame. Fellowships in groundwater physics, groundwater chemistry, anaerobic processes and bioengineering are currently available in the Environmental Engineering Program of the Civil Engineering Department. Successful applicants will be awarded annual stipends of up to $1000/mo. plus full tuition. For additional information, contact Dr. Aaron A. Jennings, Department of Civil Engineering, University of Notre Dame, Notre Dame, IN 46556 (219-239-5840).

Howard University/Graduate Assistantships in Geosciences. Howard University in Washington, D.C. offers a new graduate program for the M.S. degree in Geoscience, made possible by a grant from the Gulf Oil Company. Areas of specialization are field geology/geophysics, geochemistry, and meteorology/hydrology with remote sensing. Some stipends and assistantships are available. Potential students should write to Dr. Eric Christofferson, Department of Geology and Geography, Howard University, Wash., D.C. 20059.

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS

Meetings

Announcements

Chapman Conference on Vertical Crustal Motion: Measurement and Modeling

Call for Papers

October 22–26, 1984 Chapman Conference on Vertical Crustal Motion: Measurement and Modeling, Harpers Ferry, W. Va. Sponsor, AGU. (Vertical Motion Meeting, AGU, 2000 Florida Ave., N.W., Washington, DC 20009; telephone 202-462-6903 or toll-free 800-424-2488.)

Deadline for receipt of abstracts at AGU headquarters is August 1, 1984.

The conference will bring together scientists who measure vertical crustal motions and those who analyze and model these motions with the primary objective of obtaining close interaction between the two groups. Emphasis will be on vertical crustal movement in North America.

Measurement types to be considered are conventional leveling, tide gauges, gravity, tilt, and space systems (Very Long Baseline Interferometry, satellite laser ranging, Global Positioning System). The primary measurement questions to be addressed will be the following: (1) What are the accuracies and error sources associated with each data type? (2) What is the extent of the current data base? (3) How accurately do we know vertical crustal motions in North America? and (4) What are realistic expectations of contributions from space systems and other new technologies in the next decade?

Discussions of analysis and modeling will cover vertical motions in seismically active areas, vertical motions associated with volcanic and intrusive phenomena, and long wavelength vertical motions associated with isostatic rebound, plate edge effects (e.g., Pacific Northwest), overall North American plate motions and other eastern North American epirogenic movements (northern Louisiana/Mississippi, Appalachians, etc.) The primary analysis and modeling questions to be addressed will be: (1) What is the current status of modeling vertical crustal motions? (2) How important is vertical motion information to understanding and modeling earth dynamics? (3) What are the measurement requirements to support modeling and analysis in terms of temporal and spatial density and accuracy? and (4) What are the most critical deficiencies of vertical motion data relative to modeling and analysis?

This conference is especially timely. The large conventional leveling data base of the National Geodetic Survey has just been automated so that leveling data are much more accessible. At the same time questions and controversy have arisen regarding systematic errors in leveling. GPS systems give the potential for an increase of two orders of magnitude in the amount of space system data available in the next few years. Increasingly sophisticated analytic and finite element models are being developed that can make use of vertical crustal motion data.

Conference Format. The conference will have three sessions on each of the first 4 days with a specific focus on each day. The first two sessions each day will be given over to presentations. The third period will be for discussion. The initial presentation session each day will consist of invited papers covering the major themes of the day. The second paper session will contain primarily contributed papers. The discussion session will focus on the papers presented, but anyone will be free to bring up other points relevant to the topic of the day.

The proposed topics for the 4 days are as follows: day 1, error sources and availability of vertical crustal motion data; day 2, intercomparison and evaluation of vertical crustal motion data; day 3, analysis and modeling of vertical crustal motions in seismically active areas; day 4, analysis and models of vertical crustal motions due to volcanic, intrusive, isostatic, and epirogenic mechanisms. A half-day session will be held on the fifth day to summarize the meeting. Formal written papers will not be required. If a sufficient number of speakers is interested, approval for a special issue of the *Journal of Geophysical Research* will be sought, and papers based on conference presentations would go through the normal JGR review process to be considered for the issue.

Abstracts. To submit an abstract, follow the format published in *Eos*, January 10, 1984, p. 15. There will be no abstract charge. All abstracts should be sent to Vertical Motion Meeting, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.

Program Committee. W. E. Strange (convenor), National Geodetic Survey; J. Rundle, Sandia National Laboratory; B. Hager, California Institute of Technology; B. Tapley, University of Texas at Austin; R. Stein, U.S. Geological Survey; R. Bilham, Lamont-Doherty Geological Observatory; R. Reilinger, Air Force Geophysical Laboratory.

Spacelab 1 Results

March 27–29, 1984 Science Symposium on Initial Results from Spacelab 1, Huntsville, Ala. Sponsor, NASA. (Paul Craven, Code ES53, Marshall Space Flight Center, AL 35812; telephone: 205-453-0029.)

Preliminary results from the scientific investigations on the Spacelab 1 mission are to be presented by the principal investigators or their representatives. Five broad disciplines were covered on the flight—astronomy and solar physics, atmospheric physics and earth observations, space plasma physics, life sciences, and materials science and technology. Scientists interested in the results from any of these disciplines and as well as those with related investigations on future shuttle flights are invited to attend. In addition, all who were involved in the planning and operation of the Spacelab 1 mission are welcome. Those who wish to attend should contact Paul Craven at the above address.

Meeting Report

Magnetospheric Processes in the Plasmapause

The current experimental and theoretical status on the existence and importance of the plasmapause as a magnetospheric boundary was the subject of a Conference on Fundamental Magnetospheric Processes in the Plasmapause Region, held at Huntsville, Ala., October 25–27, 1983, under the joint sponsorship of the Marshall Space Flight Center and the University of Alabama in Huntsville. Since the last plasmapause conference, in 1974, new spacecraft and new techniques in ground-based radar measurements are providing an exciting look at the plasmapause and plasmasphere. More than 75 scientists from the United States, France, Belgium, Sweden, Japan, and the United Kingdom attended the 1983 conference.

The five major sessions to the conference were: (1) identification, formation, and structure of the plasmapause and its relationship to other magnetospheric boundaries, (2) sources and loss processes of cold and warm plasmas in the plasmapause region, (3) ionospheric trough and its relationship to the plasmapause, (4) hot plasmas in the inner magnetosphere, and (5) wave phenomena in the plasmapause region.

The first session of the conference, in addition to its stated theme, contained some interesting historical notes. Carpenter noted that Gringauz was the first to observe in situ a steep gradient in density at the edge of the protonosphere (or plasmasphere) in 1962. This finding was not generally believed by Gringauz's Russian colleagues until corroborative evidence from whistler data (taken by Carpenter) was brought to their attention. Carpenter used the term plasmapause for the density gradient and was the first to show its inward movement during periods of geomagnetic activity. Nishida, in 1966, was one of the first to explain the plasmapause as the boundary between convecting plasma and sunward flow.

In the review by Horwitz, it was noted that the plasmapause has other distinguishing characteristics, besides the well-known density gradient, that are currently being explored as indicators of its position. These indicators include, temperature increases, electric field changes, a change in the H^+/He^+ plasma from isotropic (inside) to anisotropic pitch angle distributions, and possibly the inner edge of plasmasheet electrons.

The dynamics of the plasmasphere, as reflected in the plasmapause position, was discussed by Carpenter, Decreau, Anderson, and Lemaire. Carpenter showed several examples from ground-based observations of whistlers which indicated that there are undulations in the shape of the plasmasphere with local time that could never be determined from single spacecraft observations. P. M. E. Decreau, using GEOS observations unaffected by spacecraft potential (natural impedance probe) showed that there is a longer delay in the dayside plasmapause response to a substorm than that which could be explained by purely corotation. Anderson used plasma wave emissions at the upper hybrid resonance as observed on ISEE-1 at the plasmapause to determine the in-situ plasma density. This method is also unaffected by spacecraft potential and reveals, in a radial direction, the occasional existence of high density regions just outside the plasmasphere (called detached plasma regions). Lemaire discussed how interchange motion could bring about the formation of the plasmapause boundary. Both Decreau and Gombosi showed examples of the anti-correlation between the density and temperature at the plasmapause.

Chappell reported the evidence for a wide region of warm plasma flowing in temperature) extending from the plasmapause region outward, as much as 3 earth radii. This region has been termed the "plasmaspheric cloak" since it has been observed at all local times. It is believed that this plasma population, which is higher in temperature than the ionosphere and the plasmasphere, is generated on the nightside and convects toward the dayside where it is lost at the magnetopause.

It was reported by Olsen that DC electric field measurements, from the SCATHA spacecraft made in eclipse (to overcome spacecraft charging) near the plasmapause, show no discontinuity in the electric field. The DC electric field starting at the plasmapause increases monotonically in the outward direction. Olsen also reported that during quiet times the plasma near the plasmapause seems to be slightly subcorotating with respect to the earth.

The relationship between the plasmashed and the plasmapause was explored in the talks by Horwitz, Sarand, Craven, Mauk, Spiro, Riddle, and Mewlett. Initial indications are that at storm times the inner boundary of the plasmasheet and the equatorial edge of the auroral oval coincide with the steep density gradient of the plasmapause.

Chappell, using data from the Dynamics Explorer (DE) satellite, showed examples of the newly discovered polar wind filling flux tubes over most of the magnetosphere. Moore invoked a polar wind process as a prime candidate for plasmasphere filling. Singh put forward the notion that the initial stages of plasmasphere filling involve vacuum expansion processes in which ion and electron electrostatic effects are critical. The importance of diffusive equilibrium for plasmasphere filling, as modeled by Torr using DE data, seemed to apply only inside of L = 2.2.

Heavy ion enhancements, such as O^+ and O^{++}, were reported by Roberts (from DE data) at the plasmapause to be correlated with enhancements of soft electron fluxes as measured by lower altitude instrument on DE-2. These electrons, as reported by Slater, may also be observed along subauroral red (SAR) arc field lines.

In the session on the ionospheric trough and its relationship to the plasmapause, Schunk discussed the problems involved with attributing an ionospheric feature to the position of the plasmapause. These features include the main ionospheric trough, the light ion trough, temperature maxima (Te and Ti), temperature anisotropies, SAR arcs, and plasmasheet electrons. Papers discussing ionospheric features which have been attributed to the location of the high latitude plasmapause were given by Mendillo, Brace, Grebowsky, Green, Heelis, Lockwood, Raitt, and Beghin. It was clear that no one ionospheric feature is a consistent signature of the low latitude plasmapause. Green discussed two nearly simultaneous passes of the DE-1 spacecraft over the Ghatanika Radar facility in Alaska at about 20 to 22 hours local time. Matching the invariant latitude of the spacecraft with the field of view of the radar, Green showed that the mid-latitude trough did not correspond to the plasmapause but that it fed large amounts of low energy plasma into the magnetosphere just outside the plasmapause. This region is believed to be one of the major sources of ions for the newly-discovered plasmaspheric cloak (see above).

It has been known for some time that the hot ring current particles during storm times move through the plasmapause and, by precipitation processes inside the plasmasphere, precipitate into the ionosphere. Williams recieved what is known about the cold and hot plarma interactions occurring in the plasmapause region. New results concerning this interaction show that different ion energy populations penetrate to varying depths into the plasmapause region and that the amount of available ring current energy inside the plasmasphere depends on the steepness of the plasmapause gradient. The hot distributions of plasma just outside the plasmarphere were discussed by Quiten, Lennartsson, Klumpar, and Lundin.

In the last session of the conference, Kurth described the various wave phenomena in the plasmapause region. This variety of waves included ion cyclotron, upper and lower hybrid, whistler mode, 3/2 gyroharmonic, plasmasphere hiss, and the source for continuum radiation. Nagano discursed the changes in the intensity of these waves during storm times.

Particle and wave correlations, pointed out by Olsen and Green at the magnetic equator in the region around the plasmapause, were sometimes quite dramatic. A complete change in the pitch angle distribution of the very low energy (>50 eV) hydrogen is seen from field-aligned to trapped at the equator. The characteristic temperature of the low energy plasma also increases within a few degrees of the magnetic equator, indicating a region of heating. This change in angular distribution and temperature of the low energy plarma is accompanied by intense low frequency waves. These waves have been identified as lower hybrid waves and "equatorial noise." Gallagher proposed a method of utilizing the cold plasma wave dispersion curves, together with particle and wave data, to identify wave modes and added that identification of the wave mode for equatorial noise may be accomplished with this technique.

Other aspects of particle-wave interactions were discussed by Mauk and Kozyra in the case of ion cyclotron wave growths and Thorne in the case of electron cyclotron wave growths for the intensification of plasmaspheric hiss. Kurth and Jones continued the controversy surrounding the generation of continuum radiation at the plasmapause. Observational evidence is not completely convincing for the generation mechanism proposed by Jones (Z mode conversion of ion cyclotron waves). Hughes, Cahill, and Wolfe discussed micropulsation and hydromagnetic wave events in the plasmapause region observed by ISEE, DE, and ground-based measurements, respectively. Finally, a very promising technique presented by Inan for probing the plasmapause region is through active pulsing from the Siple and Roberval ground stations, using DE conjunctions to examine the results of the stimulation. The observed triggered emissions appear to have not only single but multiple propagation paths within the plasmasphere under certain conditions.

A short discussion period, centered on various controversial aspects of the plasmapause, concluded the conference. Horwitz initiated the discussion on the question of the best definition and indicator for the equatorial plasmapause by listing some candidate plasmapause indicators: (1) the sharp density gradient, (2) a specific threshold density, (3) the transition in angle, composition, and energy characteristics of thermal ions, (4) the inner edge of the electron plasma sheet, (5) the outer edge of plasmaspheric hiss, (6) the boundary of "slow" flow trajectories (flux tubes which under steady conditions circulate near the earth for more than 2 days), and (7) the boundary between "open" and "closed" (earth-encircling) convection trojectories.

The last two definitions (proposed for the first time at this conference by Heelis) were regarded as "theoretical" plasmapause definitions, whereas the remaining ones were more direct operational indicators.

Chappell argued for the sharp density gradient as a universal plasmapause indicator when it exists, and some density level criterion for cases when the gradient is gradual. Others, such as Williams, felt most comfortable with the term "plasmapause region" denoting a regime 1 to 3 earth radii thick when the gradient is gradual. When the radial density profile exhibits only a gradual, ramp-like fall off extending to the magnetopause, Kurth and others suggested that there is no plasmapause at all. Anderson's ISEE-1 observations implied that the classic sharp plasmapause profile was rare, but Carpenter felt that a sharp drop in density at the plasmapause was at least common on the night side. In connection with defining indicators of the plasmapause, it appears that further information on the types and occurrence of different density profiles and other plasmapause characteristics were needed.

Green led the discussion on the question: What is the ionospheric signature and significance of the plasmapause? Some of those present, including Heelis, Lyons, Brace, and Kurth, expressed the view that, while investigation of the physical connection between ionospheric and plasmaspheric processes along the outer plasmaspheric flux tubes was important, the need for a plasmapause signature in the ionosphere was not critical. Chappell, referring to Schunk's presentation, acknowledged that most of the mid-latitude ionospheric signatures were inadequate in determining the position of the plasmapause. However, he did stress that features of the light ion trough should still be considered for such signatures. It was agreed that the data returned by ground-based radars in conjunction with the DE-1&2 spacecraft afforded an excellent opportunity to fruitfully explore these issues.

Other areas of scientific concern raised during this discussion period dealt with the formation of the inner edge of plasma sheet, the nature of the plasmasphere filling process, the significance of the warm anisotropic plasma in the vicinity of the plasmapause, and some of the difficulties of measuring very low-frequency (such as ion cyclotron) waves in the equatorial plasmapause region.

It was clear from the conference that the understanding of the physics in the plasmapause region is of considerable importance to understanding magnetospheric plasma circulation since through this dynamic boundary region low-energy plasma can be supplied to the magnetosphere. There are many new observations being made and concepts taking shape that will be enthusiastically pursued in the next few years by space scientists investigating plasmapause-related processes; the next plasmapause conference should not have to wait 11 years.

This meeting report was prepared by James L. Green, *who is with the Space Science Laboratory, NASA Marshall Space Flight Center, Huntsville, AL 35812, and* James L. Horwitz, *who is with the Department of Physics, University of Alabama in Huntsville, Huntsville, AL 35899.*

Chapman Conference on the Magnetospheric Polar Cap

A Chapman Conference on the Magnetospheric Polar Cap will be held August 6–9, 1984 at the University of Alaska, Fairbanks Campus. Conference co-convenors are S.-I. Akasofu and J. R. Kan

This conference will provide a unique opportunity for researchers to discuss various aspects of polar cap phenomena, the magnetotail, and the effects of the interplanetary magnetic field. The magnetospheric polar cap — the highest latitude in the upper atmosphere bounded by the auroral oval — has attracted much attention during the last several years. Discussions will emphasize an examination of how polar cap phenomena are controlled by solar wind and the interplanetary magnetic field.

There will be invited reviews and invited and contributed presentations. The Call for Papers was published in the January 24, 1984 issue of Eos. Abstract Deadline is May 1, 1984.

Limited funding is available to support student travel. The deadline date for student travel applications is May 1, 1984. Call AGU to request a travel grant application.

For information on the required abstract format or further meeting logistics, contact:
AGU Meeting Department
2000 Florida Avenue, N.W.
Washington, DC 20009
(202) 462-6903.

For program information, contact:
S.-I. Akasofu or J. R. Kan
University of Alaska
C. T. Elvey Building
Fairbanks, AK 99701
(907) 474-7282

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Exploration Geophysics

0920 Magnetic and electrical methods
(Magnetotelluric sounding)
TECTONIC STUDY OF THE CASCADE RANGE AND COLUMBIA PLATEAU IN WASHINGTON STATE BASED UPON MAGNETOTELLURIC SOUNDINGS
William D. Stanley (U.S. Geological Survey, Box 25046, MS 964, Denver Federal Center, Denver, Colorado 80225)

Data from a 400 km east-west magnetotelluric sounding profile extending from the Pacific Coast to the eastern Columbia Plateau in Washington State are interpreted to indicate as much as 10 km of conductive (2–10 ohm-m) Tertiary and possibly pre-Tertiary sedimentary and volcanic rocks. These conductive units are located beneath several km of more resistive materials in a region to the south and west of Mt. Rainier and are interpreted to be the primary cause of geomagnetic variation anomalies previously mapped in other research. Flows of the Columbia River Basalt Group are interpreted to be 3–4 km thick in the north-central part of the Columbia Plateau region where the magnetotelluric sounding profile crossed and to be underlain by 2–4 km of sedimentary rocks and interbedded volcanic flows. Data from a shorter east-west magnetotelluric profile extending from southwest of Mt. St. Helens to southeast of Mt. Adams reveal that there are major transitions in crustal electrical structure between this profile and the longer profile to the north. (Tectonics, magnetotelluric sounding, Cascade Range).
J. Geophys. Res., B, Paper 4B03F1

Geochemistry

1610 Chemistry of the atmosphere
SEASONAL, LATITUDINAL, AND SECULAR VARIATIONS IN THE ABUNDANCE AND ISOTOPIC RATIOS OF ATMOSPHERIC CARBON DIOXIDE I. RESULTS FROM OCEANOGRAPHIC CRUISES IN THE TROPICAL PACIFIC OCEAN
Charles D. Keeling, Alane F. Carter and Willem G. Mook (Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California 92093)

Between March 1979 and June 1980, air was collected on the Seven-Tabiti shuttle expedition of the Global Atmospheric Research Program. A north-south track was repeatedly sampled and the air analyzed to provide 5 sets of data on the concentration, $^{13}C/^{12}C$, and $^{18}O/^{16}O$ ratios of atmospheric carbon dioxide between 30°N and 17°S latitude near 150°W. In the northern hemisphere the $^{13}C/^{12}C$ ratio of the CO_2 seasonally added to and withdrawn from the atmosphere was found to be nearly constant at circa 30‰ less than standard PDB. This ratio is consistent with photosynthesis and respiration of terrestrial vegetation as the cause of the seasonal cycle. The ratio was progressively less negative southward, reaching circa −15‰ at 17°S. This shift in ratio suggests that air-sea exchange is important in producing the seasonal variation in the southern hemisphere, since this exchange probably occurs with little kinetic isotopic fractionation. The seasonally adjusted $^{13}C/^{12}C$ ratio of atmospheric CO_2 increased steadily southward from −7.55‰ near 16°N to −7.41‰ near 17°S, as expected from a predominately northern hemisphere source of a CO_2 from fossil fuel combustion and a barrier to atmospheric mixing in the tropics.
J. Geophys. Res., D, Paper 4D0369

Geodesy and Gravity

1905 Artificial satellite techniques
THE GRAVSAT SIGNAL OVER TECTONIC FEATURES
C. A. Wagner (National Geodetic Survey, National Oceanic and Atmospheric Administration, Rockville, Maryland, 20852), D. T. Sandwell

The range rate between two close GRAVitational SATellites in low-Earth orbit has been evaluated over model tectonic features such as mountains and ranges, fracture zones, and trenches. Models are locally compensated and consist of both point mass dipoles and sheet mass dipoles. Masses and depths of compensation are chosen to approximate known gravity signatures. The results show that for two satellites at 160 km altitude with 3 degrees separation, significant signal power (>1 micron/s) remains for most extended features at wavelengths less than 300 km. Furthermore, there is strong sensitivity in the signal from these features to lateral and vertical changes of the order of 1 km and less. In addition the signal of hidden geologic structures such as dikes, salt domes, and ore bodies may also stand above 1 micron/s for this low orbiting pair. Thus, it may prove to be efficient to model the high frequency GRAVSAT signal directly in terms of the parameters of tectonic-topographic features and their compensation. (Gravitational signatures, high order gravity, satellite measurements, simulations.)
J. Geophys. Res., B, Paper 4B0172

Hydrology

3130 Groundwater
A FINITE ELEMENT THREE-DIMENSIONAL GROUND-WATER (FE3DGW) MODEL FOR A MULTIAQUIFER SYSTEM
S. K. Gupta (Battelle Project Management Division, ONWI, Columbus, Ohio, 43201), C. R. Cole and G. F. Pinder

Using a three-dimensional isoparametric finite element scheme, a computer model, FE3DGW, is developed to simulate the steady-state and transient behavior of a large, natural, multilayered ground-water system. A hydrologic basis for developing a finite element grid is presented. Graphical displays generated by the supportive programs of the model and used to verify the input data of large, natural ground-water systems and to facilitate the interaction between modeler and field hydrogeologist are also presented. Model applications are illustrated with the simulation of a ground-water system in south Long Island, New York. The finite element solutions are compared with the electric analog model of the same region. (Groundwater modeling, finite element, three-dimensional, Long Island).
Water Resour. Res., Paper 4W0020

3140 Limnology
THE LAKE ERIE RESPONSE TO THE JANUARY 26, 1978 CYCLONE
J. Istvan Pingman (Department of Civil Engineering, The Ohio State University, Columbus, Ohio, 43210), and Keith W. Bedford

A descriptive analysis of the response of Lake Erie to the passage of the blizzard cyclone of January 26, 1978 is presented. This intense extratropical cyclone, the worst ever to cross the Ohio Valley and Great Lakes region of the United States, set numerous record low sea level pressure readings at nearly every recording station surrounding Lake Erie, and subjected the lake region to sharp temperature drops and high winds. The lake surface was significantly ice covered during the storm event; it remained virtually intact on the entire Western Basin and partial ice cover break-up occurred over the Central Basin. The investigation of the water level fluctuations induced by the cyclone are based on data aquired from normal meteorological and water level monitoring stations surrounding the lake. The most unusual aspects of the water surface fluctuations include: the observance of a pressure suction induced rise in water level in the Western Basin before the storm passed north of the lake; a maximum storm surge set-up occurring between Marblehead, Ohio and Port Colborne, Canada and not between the ends of the lake, and a separate oscillatory surge occurring at Port Stanley, Canada. The probable causes and reasons for these fluctuations are thoroughly analyzed in the context of existing theories that deal with how a lake surface responds to external atmospheric forcing functions such as wind stress, sea level pressure changes, and resonance. The effect of the ice cover on the water level fluctuations is also presented. (Storm surge, resonance, meteorology, Lake Erie).
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